July 2004

City of Redmond

Hazard Mitigation Plan

Document Two:

Hazard Identification Vulnerability Analysis (HIVA)

HAZARD IDENTIFICATION VULNERABILITY ANALYSIS (HIVA)

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EXECUTIVE SUMMARY

The City of Redmond is susceptible to many natural, technological, and human-caused hazards. Knowledge of these hazards, their frequency, and the community's vulnerability to them allows the community, emergency managers, police, fire, and medical agencies to better assess their risks associated to the present hazards and to plan and prepare for their consequences.

The purpose of this document is twofold:

1. To provide a basic level of knowledge and limited analysis of the hazards posing a threat to the City of Redmond.
2. To serve as base document for the City Comprehensive Land Use Plan, the Hazard Mitigation Plan, and Comprehensive Emergency Management Plan.

This document represents an elementary review of available published material. It is a summary of the relevant information needed to allow a subjective evaluation of the risk posed by certain hazards. It is not, nor is it intended to be, a rigorous or scientific analysis.

Relative Risk Assessment

Based on the individual hazard profiles and risk assessments contained herein, the project team has ranked the risks according to hazards.

1. Earthquake
2. Landslide
3. Flooding
4. Winter Storms
5. Terrorism

Since a major earthquake is very probable in the Cascadia Region within the next 25 years with anticipated severe impacts to the region at large, including the entire Redmond population, this hazard is given the highest risk rating. Structures located on soft alluvial soils, along or below steep slopes and along the Lake Sammamish shoreline are particularly vulnerable in an earthquake and in the event of an earthquake's many secondary hazards such as landslide, fire, and seiche.

Landslides are assigned the second highest risk rating, as Redmond topography is characterized by several steep slopes, has experienced heavy mudslides in recent history, and can be triggered by several probable events such as earthquake and heavy rains. While impacts are tempered somewhat by quality engineering and construction practices, as well as ample vegetation structure, this hazard is given a medium risk rating overall.

Flooding risk exists but varies by location, impact, and source. There is a high probability of low impact flooding along Bear Creek and Evans Creek, and thus a low risk rating. There is low probability of low impact flooding along the Sammamish River, and thus a low risk rating is assigned. There is a low probability of low impact flooding along the shores of Lake Sammamish, and thus a low risk rating is assigned for flooding in this area.

Terrorism and Winter Storms are tied for fourth and fifth highest risk rating. While Terrorism is a relatively infrequent event, its probability seems to be increasing. Given that Redmond is an "international crossroads" of sorts, with a number of multinational corporate headquarters located within its boundaries, we have assigned a high vulnerability rating for focused populations that are potential "targets" for terrorist activity.

Hazard	Hazard Severity + Location + Frequency/Probability	Vulnerability Natural + Manmade + Systems	Total Risk Hazard Risk * Vulnerability /Capability	Page
Drought	Moderate	Low	Low	5
Earthquake	Moderate	High	Moderate -> High	8
Epidemic	Low -> Mod Severity Low -> Mod Probability	Low -> High Impact	Low	12
Flooding	Bear & Evans Cr. – high Sammamish R. – low L. Sammamish – low	Low Low Low	Moderate Low Low	15
Hazardous Materials	Low -> High	Low	Low ->Moderate	20
Heat Wave	Low	Moderate	Low	22
Landslide	High	Moderate	Moderate -> High	24
Terrorism	Low -> Moderate	Low -> Moderate (Depends on target)	Moderate	27
Wildfire	Low -> Moderate (Seasonal)	Low -> Moderate (Depends on if drought)	Low -> Moderate	29
Winter Storm	High	Low	Moderate	33

UNDERSTANDING RISK RATINGS

To make the analysis more useful, adjective descriptors (High, Medium, Low) are established for each hazard's probability-of-occurrence and the area's vulnerability in the event of the hazard. A risk rating is assigned on the probability of a hazard occurring over the next 25 years. This interval was chosen because it is the long-term recurrence interval of a dangerous earthquake, the hazard of greatest risk to the City of Redmond. A final risk rating is assigned based on a subjective estimate of their combination and ultimately will help focus the emergency management program on the events with greatest potential risk.

A “High” risk rating warrants major program effort to prepare for, respond to, recover from, and mitigate against the hazard. A high risk rating for a hazard means that the hazard has a high probability of occurrence, and the entire population of Redmond is vulnerable to the hazard.

A “Medium” risk rating warrants modest program effort to prepare for, respond to, recover from, and mitigate against the hazard. A medium risk rating for a hazard means that the hazard has a moderate probability of occurrence, and/or only a part of the entire population of Redmond is vulnerable to the hazard.

A “Low” risk rating warrants no special effort to prepare for, respond to, recover from, or mitigate against the hazard beyond general awareness training. A low risk rating for a hazard means that the hazard has a low probability of occurrence, and/or only a small segment of the population in Redmond is vulnerable to the hazard.

Hazard Profile – Hazards were assessed as to location, severity, warning time (where relevant), and the probability of occurrence.

A hazard rating was offered that considered each variable in the assessment and was based on a limited objective appraisal using information provided by relevant sources, observations, and trends.

HIGH: There is great likelihood (probability) that a hazardous event (severity, location, and warning) will occur within the next 25 years.

MEDIUM: There is moderate likelihood that a hazardous event will occur within the next 25 years.

LOW: There is little likelihood that a hazardous event will occur within the next 25 years.

Vulnerability – An adjective description (High, Medium, or Low) of the potential impact a hazard could have on Redmond. It is the ratio of population, property, commerce, infrastructure, and services at risk relative to the entire City. Vulnerability is an estimate generally based on a hazard's characteristics. A High rating would indicate a significant impact throughout the entire City, a Medium rating would indicate an isolated significant impact or a moderate impact throughout the entire City, and a Low rating would indicate an isolated moderate impact in a selected area or a limited impact throughout the City.

Capability – Refers to the tools available to reduce the risk. An example is the ability to fight fire and avert a disaster.

Primary and Secondary Hazards – Hazards are identified as being either primary or secondary. A primary hazard is the initial hazard responsible for the potential danger to life or property. Most often the primary hazard triggers a wide range of secondary hazards. Secondary hazards are attributable to a primary hazard; thus we view a landslide as most often a secondary hazard to earthquakes or flooding. Similarly, think of unsecured furniture as a secondary hazard to earthquakes.

THE CITY OF REDMOND - PROFILE

Redmond is the sixteenth largest city in the State of Washington, with a residential population of 45,256. It encompasses an area of over 16.6 square miles and is located less than 20 miles east of downtown Seattle. Redmond sits at the north end of Lake Sammamish and covers the surrounding hills. Tall evergreen forests and salmon spawning streams are natural to the area. Logging and agriculture provided the early economic base of the area. Now numerous business parks are home to the area's manufacturers and high-tech businesses.

Redmond enjoys a diverse and growing economic base. In fact, Redmond's 52,812 employees outnumber the City population of 45,256. The community is home to some of the major high-tech firms in the country, including Microsoft, Nintendo of America, Honeywell, and Primex Aerospace Company. Redmond is also the headquarters of such businesses as Eddie Bauer and Genie Industries and the regional headquarters of Safeco Insurance. Seven of the top 16 biomedical companies in the Puget Sound region call Redmond home – topped by Spacelabs Medical and Medtronic Physio-Control Corporation. Physio has gained national prominence with the growing use of defibrillators to treat heart attack victims.

A strong retail sector is enhanced by Redmond Town Center, a 1.4 million square-foot mixed-use development that includes retail stores, restaurants, and commercial offices. From an original incorporated area of three-square blocks, the City has expanded to its present size of over 16.6 square miles. Regional growth around the Eastside will continue to impact Redmond as more people and businesses are attracted to the area.

The elevation at city center is 50 feet. The annual mean temperature is 52.8 degrees, and the average annual precipitation is 35.50 inches. In 1960, the population of Redmond was 1,426. As of April 2001, the population of Redmond was recorded at 45,256.

From 1996 to 1999, 240 acres of wildlife habitat have been converted to development. Recently, the City has undertaken restoration work along the Sammamish River, Peters Creek, and Bear Creek. A U.S. Fish and Wildlife survey conducted in September 1998 showed that both Chinook and Sockeye were found in the City's first Sammamish River restoration site.

The City has established a transfer of development rights program designed to protect open space, agricultural land, and wildlife habitat in the City. The City is developing a Wildlife Habitat Plan that will provide the framework for an overall strategy for wildlife habitat management in Redmond, and has established regulations to preserve trees.

DROUGHT

I. Hazard Profile

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, although its characteristics vary significantly from one region to another.

Drought originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought should be considered relative to some long-term balance,

timing, and effectiveness between precipitation and evapo-transpiration. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with it in many regions of the world and can significantly aggravate its severity.

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human beings often exacerbate the impact of drought.

Source: "Understanding and Defining Drought," First published: November 15, 1995 by the National Drought Mitigation Center, http://enso.unl.edu/ndmc/enigma/def2.htm

Secondary hazards that could result from drought may include:

- Fire
- Landslides (defoliation followed by rains)
- Economic Impact

A. Location

The Redmond residential and business communities are vulnerable to drought or any loss of water.

http://www.wrh.noaa.gov/afos/SEA/ESF/SEAESFSEA

The Drought Monitor of the National Drought Mitigation Center maps the extent and degree of drought conditions for the United States. There is no single index of drought; therefore, "the Drought Monitor [is] a synthesis of multiple indices, outlooks, and news accounts that represents a consensus of federal and academic scientists." Drought maps are available at http://enso.unl.edu/monitor/monitor.html

B. Severity

"Drought conditions have differing impacts on the community during different times of the year. A drought during the winter, which limits snow pack, might have a more severe impact on the community than one in the late summer when reservoirs can be used to mitigate problems. There are also certain times during a growing season when crops are better able to cope with drought conditions than others; therefore, crop yields can vary greatly depending on when in the growing season the drought occurs." (KCOEM)

C. Probability

Since 1900, about fifteen droughts of various duration have affected the Puget Sound Region. The King County Office of Emergency Management lists the most significant droughts affecting the Puget Sound region in the past thirty-five years as:

1965-1966: The entire state was affected by drought conditions. King County recorded Palmer Indexes of roughly -1.5 from June 1965 to December 1966.

June-August 1967: No rain fell from the third week in June to the third week in September. 1,767 fires burned throughout the state.

October 1976-September 1977: King County experienced precipitation levels 57 percent of normal. Stream flows averaged between 30 and 70 percent of normal. Temperatures were higher than normal, which resulted in algae (sic) growth and fish kills.

October 1991-September 1994: Stream flows were between 30 and 60 percent of normal. Agriculture products suffered greatly. Thirty counties were designated as Emergency Drought Impact areas.

The governor declared the most recent drought in March of 2001.

The possibility of drought affecting Redmond is moderate when the history of drought in the region is considered overt the past one hundred years.

D. Warning

The State of Washington codifies an operational definition of drought. The State of Washington Department of Ecology is responsible for issuing drought emergency recommendations to the governor. Under Washington state law (Chapter 43.83B RCW - Water Supply Facilities), two criteria must be met in order to declare a drought. First, the water supply must be less than 75 percent of normal. Second, the shortage must create undue hardship for some users.

"On March 14, 2001, under recommendation from the Department of Ecology and the Executive Water Emergency Committee, Governor Gary Locke declared drought status in Washington State."

From "Drought Declared In Washington" Drought homepage, Washington State Department of Ecology, Water Resources Program
http://www.ecy.wa.gov/programs/wr/drought/droughthome.html

II. Vulnerability and Impacts

A. Natural

Reduced stream flows impact aquatic life. An effect of wildfire, a secondary hazard, is the siltation of waterways from the increased rate of water run-off over the landscape after a fire. Salmon and trout are especially sensitive to reduced flows, siltation, and associated increases in water temperature.

B. Manmade

Lawns and gardens and irrigated landscapes (golf courses) are vulnerable to drought conditions.

C. Systems

In a drought, the reduction of the amount of available water in reservoirs intensifies the debate over water allocation among agricultural irrigators, municipal water authorities, environmental agencies, industrial users, and tribal nations. The debate is further complicated in an energy crisis, as much of the region's power derives from hydroelectric power plants.

III. Risk Rating

Redmond faces a moderate risk of a drought in that there is a moderate probability of occurrence, and the entire region is vulnerable to this. The risk is shifting as the demand for water regionally approaches the demand. Further, the system is exposed to other hazards that can impact the water system during a drought.

IV. Capability

Redmond has an emergency plan for dealing with water shortage. One of the tenets is the voluntary reduction of water usage in order to avoid mandatory water rationing. Since droughts have a long onset, the policy starts early. This has been effective in the past. Further, Redmond's wells have a different cycle than the regional reservoirs. When managed as a reserve, they add to Redmond's capability; however, the regional demand is moving toward the regional capacity. If this trend continues, capability will be readily stressed.

V. Links

Social Aspects of Weather: Summer/Winter. National Center for Atmospheric Research Environmental and Societal Impacts Group
http://www.esig.ucar.edu/socasp/summer-winter.html

King County Office of Emergency Management, "Natural Hazards: Droughts"
http://www.metrokc.gov/prepare/hiva/drought.htm

City of Seattle, Seattle Public Utilities, "Current Water Supply Conditions and Outlook"
http://www.cityofseattle.net/util/watersupply/current.htm

http://www.ci.redmond.wa.us/insidecityhall/publicworks/environment/conservation.asp

EARTHQUAKES

I. Hazard Profile

The Earth is formed of several layers that have very different physical and chemical properties. The outer layer, about 70 kilometers in thickness on average, consists of about a dozen large, irregularly shaped plates that slide over, under, and past each other, on top of a partly molten inner layer. Within these plates are three types of boundaries: spreading zones, transform faults, and subduction zones.

An earthquake is the vibration, sometimes violent, of the Earth's surface following a release of energy in the Earth's crust. The energy can be generated by stress on the Earth's plates, by volcanic eruptions, and the plates buttressing up against one another generating friction. Dislocations of the Earth's crust cause the most destructive and catastrophic quakes. The crust comes apart at the seams. When this happens, the crust might bend or move parallel to each other and, when the stress exceeds the strength of the rocks, break and "snap" to a new position causing the ground to shift. This movement in turn dislocates, ruptures, or damages objects that sit atop the Earth's crust.

There are three types of earthquakes that the Puget Sound region could experience along these faults:

Deep Earthquakes

Deep earthquakes occur within the Juan De Fuca Plate as it sinks into the mantle. They are at depths of 25-100 km. The largest of these recorded were the magnitude (M) 7.1 Olympia earthquake in 1949 and the M6.5 Seattle-Tacoma earthquake in 1965. Due to their depth, aftershocks are not usually felt. There have been six deep earthquakes in the Puget Sound basin with measured or estimated magnitudes of 6.0 or larger. The most recent deep earthquake was felt in Redmond on February 28, 2001. Its epicenter was beneath the Nisqually Delta near Olympia, Washington and measured 6.8 on the Richter scale.

Shallow Earthquakes

Shallow earthquakes occur within the North American Plate itself, within 30 km of the surface, and are thought to originate from stress transmitted from the Cascadia Subduction Zone into the interior of the North America Plate. Several recent moderate examples occurred throughout Washington and most parts of Oregon, measuring between M5.0-6.0: in 1995, 1993, 1990, 1962, 1945, and on the Mt. St. Helens seismic zone in 1981. Larger quakes of magnitudes 5.9 and 6.0 occurred near Klamath Falls, Oregon.

The Seattle Fault that runs east-west through Seattle and Issaquah and terminates near Preston. The Southern terminus of the South Whidbey Fault is near Woodinville. Each of these faults is capable of producing a 7+M, shallow earthquake in close proximity to Redmond.

Subduction Zone Earthquakes

Subduction zone earthquakes occur along the interface between tectonic plates, most tending to be deep below the earth's crust where the denser plate of earth slides under the less thick or dense plate.

Compelling evidence for great-magnitude earthquakes along the Cascadia Subduction Zone has recently been discovered. These earthquakes can be enormous (M8-9+) and reoccur approximately every 550 years on average. As two thick plates crash into each other, they form broken-faulted mountains. The recurrence interval, however, has apparently been irregular – as short as about 100 years and as long as 1,100 years. The last of these great earthquakes struck Washington about 300 years ago.

Secondary hazards may include:

- Liquefaction and subsidence of soils
- Landslides impacting transportation, homes, and public infrastructure
- Seiche or sloshing water impacting shoreline developments
- Fires

The severity of soil-related natural hazards and ground failure phenomena often depends on status of groundwater, rainy seasons, and drought conditions.

For more information about earthquakes:
http://www.geophys.washington.edu/SEIS/PNSN/INFO_GENERAL/NQT/what_causes.html

A. Location

The Seattle Fault, the South Whidbey Fault, and the Cascadia subduction zone are the most likely major problems for Seattle. The soils in the Sammamish Slough and Bear Creek drainages are glacial fill and will liquefy. Redmond is largely developed in these valleys. This includes the City Campus.

In a regional event, Redmond is vulnerable to the loss of electricity, water, and transportation.

B. Severity

The two most damaging earthquakes in Washington State happened in 1965 – a magnitude 6.5 quake located between Seattle and Tacoma and a magnitude 7.1 in Olympia. Both quakes caused significant damage throughout the region.

The recent February 28, 2001 Nisqually earthquake measured a magnitude 6.8, a Benioff earthquake originating thirty miles below the surface, near Olympia, Washington. Because of the depth of the earthquake, it was far less destructive than it could have been if nearer to the surface.

The Cascadia, South Whidbey, and Seattle fault events will cause liquefaction of the soils in Redmond. These events will also create regional lifeline problems. Lifeline issues will impact the Redmond economy and recovery.

C. Probability and History

Worldwide there are 18 magnitude 7 to 7.9 earthquakes per year, but these are concentrated in a few narrow regions of the world. Although there is no sure way to predict an earthquake, there is a regular pattern of occurrence in the Puget Sound region.

Since 1980, the Pacific Northwest has had an average of more than 2,000 earthquakes (per what?). The vast majority are shallow earthquakes (>98%) with a magnitude of less than 3.0 (>99%). Geologic evidence indicates that the Cascadia Subduction Zone has generated great earthquakes at roughly 500-year intervals, most recently about 300 years ago. Further, major events on the Seattle and Whidbey faults appear to occur at a rate of between 700 and 1,500 years. The cumulative probability of a major event that would impact Redmond may be 20-60% in 100 years. This assumes that subduction is occurring at the historic rate.

II. Vulnerability

Redmond's 45,256 residents are vulnerable to an earthquake in various degrees depending on the location of the individual at the time of the event. Possibly the most detrimental damage to Redmond would come from a potential quake along the Seattle fault line. A Cascadia Region subduction zone quake could result in a minimal amount of damage to the City depending on the magnitude.

The City's central business district is built upon soft soils that could liquefy during seismic activity. Manmade structures are vulnerable depending on soils, when they were built relative to uniform building codes, and if made from un-reinforced masonry. Public infrastructure, such as the Olympic Pipe Line, water distribution line, bridges, streets, and possibly the infrastructure in Old Redmond Town Center, are vulnerable to ground failure and liquefaction impacts, depending on the magnitude and type of quake hitting the region.

Although the 2001 Nisqually earthquake could be felt as far south as Oregon and as far north as Vancouver B.C., Redmond did not suffer extensive damage but did experience minor liquefaction.

Potential manmade hazards related to an earthquake event include:

- People stranded if transportation or other lifeline networks fail. Redmond may be unsupported if the disaster is region-wide.
- Chimneys, bricks, trees, displacement of homes, bridges, and un-reinforced structures.
- Elevated concrete or brick walkways.
- Cracks in roads could cause accidents.

Finally, potential system vulnerabilities include:

- Business interruption and resulting losses in sales, wages, and profits from businesses.
- Redmond's local economy would be impacted if economic processes break down, but more likely are potential worldwide business impacts since the City is headquarters to many multinational corporations.

III. Risk Rating

The earthquake risk rating is high. The combination of the high vulnerability of the infrastructure, critical facilities, the economy, and the close proximity of highly volatile faults justify this rating.

IV. Links

For further information on earthquakes please refer to the following links:

http://www.crew.org
http://www.usgs.gov
http://earthquake.usgs.gov/activity/latest/eq_01_02_28.html
http://maximus.ce.washington.edu/~nisqually/
http://beagle.ceri.memphis.edu/public/eqinfo.shtml
http://www.geophys.washington.edu/SEIS/PNSN/INFO_GENERAL/NQT/what_causes.html

EPIDEMICS

I. Hazard Profile

An epidemic is the outbreak of disease beyond its endemic rate. One of the most common causes of epidemic is the influenza virus. The earliest worldwide outbreak of influenza in recent times occurred in 1918-1919, when an estimated 20 million people died – more than 500,000 in the United States alone. The "Asian Influenza" of 1957 swept over the world quickly and resulted in 750,000 fatalities in America. In 1968, the "Hong Kong Influenza" generated an even higher number of fatalities. Every spring, the World Health Organization makes predictions for the flu strains most likely to strike in the coming flu season, generally November through April. Even with this kind of advance warning, influenza epidemics have the potential to pose serious risk. Influenza is one of the oldest and most fatal diseases known to mankind. Epidemiologists expect outbreaks from new viruses like SARS to become more common in the future.

There are other types and sources of epidemics as well. Biological weapons are another potential source of epidemic. The most likely biological weapons include Anthrax, smallpox, tularemia, viral hemorrhagic fever, and toxin. The estimated mortality for a population of 500,000 in the face of 50 kg of a biologic toxin in aerosol form is as follows: Anthrax, 95,000 dead; Tularemia, 35,000 dead; Typhus, 19,000 dead. Obviously, the severity of a potential epidemic as a result of biological warfare would be great.

Food-borne illness also poses a risk of epidemic. The frequency of serious gastrointestinal illness is 34 percent above what it was in 1948, according to the Centers for Disease Control and Prevention. Every year the agency says 5,000 deaths, 325,000 hospitalizations, and 76 million illnesses are caused by food poisoning, with questions regarding the safety of imported, contaminated products. Public water systems also have the potential to be sources for epidemic disease.

In May of 2000, five people were killed and hundreds were sickened with an intestinal bacteria found in the local water supply. According to the Canadian Health Ministry, the greater Vancouver water supply is responsible for about 17,500 gastrointestinal illnesses each year, including three deaths apparently due to too few filtration systems. Public water sources are always vulnerable to resistant strains of parasites and bacteria.

According to the King County Health Services Communicable Disease Center, there is also the potential for an epidemic from sexually transmitted diseases in King County. Johns Hopkins University reports that gonorrhea is the most commonly reported infectious disease in adults, with more than 875,817 cases reported between 1992-1994. In Sub-Saharan Africa, 26 million people have AIDS. In 2000, more than 2.4 million people died from AIDS in the region.

The hoof and mouth epidemic that is ravaging Great Britain's livestock industry has US cattle producers worried. Experts predict that it is only a matter of time before the disease makes its way into this country on the sole of a traveler's shoe or a stray bit of imported food stuff. With nearly 2,000 confirmed cases of the disease reported, the epidemic has already cost British companies $30 billion.

Clearly, every community is exposed to the risk of epidemics at some level. The questions are: what is the severity of the risk, what areas are vulnerable, and what is the probability of the hazard of an epidemic?

Secondary hazards that could result from epidemics may include

- Economic impacts.
- Reduced response.

A. Location

Various locations in the City of Redmond would be exposed to the hazards of an epidemic, depending on the type of epidemic. Retirement homes, hospitals, and daycare centers are locations where the more vulnerable members of a community are often brought together. Those members of the community who have compromised immune systems, the elderly, and very young children, are especially vulnerable to epidemics such as influenza.

All of Redmond would be vulnerable to a biological weapons epidemic. More densely populated areas, such as an apartment complex, mall, school, or large office building, would be more likely to be targeted.

Hoof and mouth disease or other animal-borne epidemics would be located in agricultural areas. Although Redmond does possess large tracts of agricultural land, the Redmond Department of Business Licenses reports that there are no licensed livestock businesses operating in Redmond.

B. Severity

The severity of an epidemic would depend on the disease itself. There are influenza events affecting a large percentage of the population every year during the flu season, but if it is a mild strain, the severity of the epidemic is greatly lessened. If a particularly virulent influenza virus occurred, there is a great potential for an epidemic of high severity.

A biological weapons attack has the potential to be of enormous severity to the population of Redmond. An outbreak of food poisoning could also be severe, although the effects of the severity would be localized among those who ingested the contaminated food or liquid. An epidemic from such sexually transmitted diseases as gonorrhea would be far less severe than an epidemic of the AIDS virus.

C. Probability and History

There is no history of serious epidemic disease in Redmond in recent times. Nonetheless, the King County Health Services Communicable Disease Center warns that in the presence of a growing population, there is more opportunity for infectious disease to occur and spread. In the last ten years, the population of Redmond has increased 26.4%. As such, there is reason to believe that the probability of an epidemic in Redmond is proportional to the increase in population. The probability of epidemic from a mild form of influenza virus is high, while the probability of a severe form of the influenza virus is low.

The worldwide occurrence of epidemics as a result of biologic warfare is very low, and as such, a low probability rating is assigned to the hazard of epidemic from biological weapons.

While strict Health Department regulations on sanitary food handling and preparation offer some protection from the risk of disease from contaminated food, the risk nonetheless increases as

the number of opportunities increases. As such, the risk of a food-borne epidemic is moderate. The risk of public water supply contamination is also moderate.

The probability of a sexually transmitted disease (STD) epidemic from a source such as gonorrhea is moderate to low, given the presence of STDs in the general population. The probability of a sexually transmitted and blood-borne epidemic such as AIDS is low because of the relative percent of infection in the general population in the geographic region of Redmond. Nonetheless, King County health officials are planning to issue a public warning that the AIDS virus infections may be increasing at an alarming rate among gay men.

Dr. Bob Wood, AIDS Control Officer for Public Health in Seattle and King County, told a state advisory committee on the disease that it appears a "new wave" of infections is hitting the area. The increases, he said, are a result of people relaxing cautions about sexual practices that spread the virus. Worries have subsided because new drugs extend the lives of AIDS patients, and people are burned out on the "safe sex" message, he said.

D. Warning

An influenza epidemic could have some warning in that most people would know to expect the presence of the flu virus from November to April. That, coupled with the WHO predictions every spring, serves as warning for most types of potential flu epidemics.

A food- or water-borne epidemic would have no warning, although it would likely be only a short period of time before the cause of the epidemic was identified and resolved. A sexually transmitted disease epidemic would have considerable warning, and most susceptible segments of the population could take precautions against infection. An animal-related epidemic, such as hoof and mouth disease, might have ample warning but still be vulnerable due to the nature of the disease.

II. Vulnerability

A. Natural

There would be little threat to the natural environment as a result of an influenza epidemic, food-borne, or sexually transmitted epidemic. The natural environment would be assigned a low impact/low vulnerability rating for these types of epidemics. It is possible that the natural environment, particularly fish and wildlife, would suffer catastrophically in the event of a biological weapons epidemic. For this reason, the natural environment would be assigned a high impact, high vulnerability rating.

B. Manmade

The manmade environment, such as homes, businesses, and other essential infrastructure, is not vulnerable in the event of an epidemic. Therefore, the manmade environment is assigned a low impact, low vulnerability rating for an epidemic.

C. Systems

In the event of a catastrophic epidemic (such as biological warfare or a deadly strain of influenza), community systems would be severely strained as hospitals and morgues filled up with the victims of the epidemic. Police and emergency caregivers would be heavily impacted.

The long-term costs related to health care and the potential need for child placement (as in AIDS-ridden Africa) could be astronomical. There would also be significant impact due to the loss of productivity and the disruption of services caused by a high impact epidemic. In the event of severe and widespread epidemic, there would be a high impact/high vulnerability rating.

For other forms of epidemic, a low impact, low vulnerability rating would be assigned to community systems.

III. Risk Rating

An epidemic can be given a high, moderate, or low risk rating depending on the type of epidemic. In general, a severe epidemic would have a high impact but low probability and, as such, would have a low risk rating. An epidemic such as a low severity strain of the influenza virus would have a moderate probability and low impact and, as such, a low risk rating. An epidemic caused by mass food contamination or sexually transmitted diseases would have a moderate severity rating, a low probability, and thus a low risk rating.

IV. Links

http://www.hopkins-id.edu
http://www.seattletimes.nwsource.com.news
http://www.fkmedical.com/fk2.html
http://www.upwardquest.com/plague.html
http://www.discovery.com/exp/epidemic/epidemic.html
http://www.unaids.org/epidemic_update/repo
http://www.who.int/emc/diseases
http://www.pbs.org/wgbh/pages/amex/influenza

Flooding

I. Hazard Profile

Floods have caused a greater loss of life and property and have disrupted more families and communities in the United States than all other natural hazards combined. Redmond contains four principle bodies of water: the Sammamish River, Bear Creek, Evans Creek, and Lake Sammamish.

In 1963, the Army Corp of Engineers, in coordination with King County, re-engineered the Sammamish River that historically had left its banks, causing moderate flooding in downtown Redmond. Since that time, the Sammamish River itself has not flooded. Any flooding events related to the Sammamish River are the result of backwater flooding, when surface water discharge spills onto City streets and nearby development due to peak river conditions and reduced river capacity.

The Bear Creek basin has a history of flooding. Development regulations predicated on FEMA floodplain determinations and a local designation of a zero-rise floodplain along Bear Creek in the area upstream of Redmond Way to the City limits, including the area of Evans Creek, have helped to curtail vulnerable construction practices. Further regulations relating to fill practices within the designated Urban Conservancy area along Bear Creek and the Sammamish River

have also helped to protect the storage capacity of the floodplain. Any development activity in the floodplain of the Bear Creek and Sammamish River Urban Conservancy area is required to provide storage for each yard of cubic fill added to the floodplain. In other words, for each yard of fill added to the floodplain in the Urban Conservancy area in Redmond, a cubic yard must be removed in some other area of the floodplain in order to compensate for the reduced storage capacity associated with the development activity.

The Bear Creek Basin plan has also contributed to the stability of Bear Creek and Evans Creek. The overall plan addresses flooding, erosion, and habitat protection by recommending 65% forest retention in the Bear Creek Basin. Redmond adopted this recommendation as a planning regulation for the Bear Creek Basin. By retaining forested cover, the hydrologic absorptive capacity of the riparian areas in the Bear Creek Basin is preserved, thus reducing the risk of flashy water flow conditions that could otherwise lead to scour, downstream gravel recruitment, erosion, and sedimentation.

Federal disaster aid was made available in King and Snohomish counties in 1997 to help communities in Washington State recover from winter storms. Flooding, mud, and debris caused the damage. We can expect continued flooding because human activities increase impervious surfaces. Paving roads and parking lots reduces water filtration into aquifer recharge areas and increases runoff into streams and lakes. In the past 20 years, the population in Redmond has increased approximately 254%, and the number of businesses has increased by approximately 708%. It is projected that by the year 2012, Redmond's population will increase by 16,563 more residents, 9,878 more houses and 29,500 more jobs. All of these factors contribute to an increase in impervious area and, therefore, an increase in the potential for flooding in Redmond.

Secondary hazards that could result from flooding may include

- Land slides
- Hazardous waste contamination
- Economic disruption

A. Location

The area most commonly affected by flooding events is along Bear Creek, north of Redmond Way and south of Union Hill Road. Flood flows along Bear Creek have increased as development along Bear Creek increases, again, as a result of increased impervious surfaces. Before the early 1990's, the area between Bear Creek and Union Hill Road frequently flooded. A public works project known as the "Stewart Fill" remedied most of this situation; however, flooding along Bear Creek continues to be a problem.

Most of downtown Redmond that lies within the 100-year flood plain of the Sammamish River has been built under regulations set forth by the Federal Emergency Management Agency (FEMA) based on the Flood Insurance Rate Maps (FIRM) that were created by the Army Corp of Engineers. Elevation reference marks are found on all flood maps. These marks identify points where a ground elevation is established by survey. In order to build in an identified flood plain, developers must raise the grade of the finished floor one foot above the flood plain elevation.

In the case of Redmond, the elevation of the 100-year flood plain is approximately 12 inches higher in elevation than those areas outside of the flood plain. Few locations along the

Sammamish River are vulnerable to flooding, except in the instances of backwater flooding. The area most commonly affected by backwater flooding is beneath the railroad tracks along Redmond Way. This area flooded during the heavy snows and subsequent melt-off related to the winter storm of 1997. At that time, four lanes of Redmond Way were closed, and traffic through the area was diverted to other streets.

Other locations of potential flooding are the low-lying basins close to Lake Sammamish. These areas are susceptible to backwater flooding.

B. Severity

The severity of flooding in Redmond needs to be assessed on a system-by-system basis. The backwater flooding along the Sammamish River system is only problematic in times of heavy rain. The river itself does not leave its bank. The problem of localized flooding along Redmond Way beneath the railroad tracks is not so severe as to warrant any public works projects aimed at correcting the drainage in the area. When Redmond Way is flooded in this area, traffic is simply diverted. As such, flooding events associated with the Sammamish River are given a low severity rating.

The flooding events along Bear Creek are also given a low severity rating, even though Bear Creek often floods. This low severity rating is based on the development regulations that Redmond has established for a zero-rise flood plain overlay for Bear Creek, in addition to the one-foot rise floodway established by FEMA. While FEMA's flood elevation is based on current flow analysis, the zero-rise flood plain requires that all new development applications submit an analysis of the zero-rise elevation for the project.

This zero-rise elevation must be based on a future flow analysis using the Redmond Comprehensive Plan designation for the entire Bear Creek basin. Thus, the required zero-rise elevation is based on where the flood plain will be when the area is built-out per comprehensive designation. This projected elevation will be relative to the amount of impervious surface that will be associated with a fully developed area and reflect an elevation that will more accurately anticipate the building elevation necessary to insure protection against future flooding events. As such, the severity of flooding in the Bear Creek flood plain is greatly mitigated by comprehensive public works and land use regulatory mechanisms.

It should be noted that both public and private development activity in the Bear Creek Urban Conservancy is subject to the zero-rise flood plain regulations. This means that public streets and bridges are also being built to standards that will anticipate potential future flooding conditions. In that the Bear Creek Urban Conservancy area is expected to experience intense development pressure as Redmond itself grows, it is especially important that the associated effects of increased impervious surfaces be factored into the flood plain management plan for the area.

The severity of flooding related to Lake Sammamish is given a low rating. It requires a very high-volume flooding event to raise the water level in Lake Sammamish. As such, flooding events are minor and infrequent.

C. Probability

Redmond has recently experienced a number of flooding events and associated hazards, such as slides, sink holes, and road closures. During the January storm of 1997, twenty-nine roads

in King County remained closed due to slides, floods, and sinkholes. Included in this count were sections of Sahalee Way Northeast and Southeast Duthie Hill Road on the Sammamish Plateau in Redmond.

The January 1997 storm also shut down five streets because of flooding. A hazard associated with that storm was a 200-foot-long mudslide that forced the evacuation of 35 residents along 180th Avenue Northeast. The slide cut off the only road to seven houses in the area and prompted the evacuation of nearby condominiums.

In February of 1996, Patterson Creek east of Redmond cut a new path, spilling over its shallow banks and roaring across the Redmond-Fall City Road.

In November of 1998, East Lake Sammamish Parkway Northeast, south of Redmond, remained closed after rainfall and a broken water main caused part of the road to drop into a 25-foot sinkhole on Friday. King County transportation crews worked through the night to stabilize the road so it could be repaired.

While there is a history of flooding and other hazards associated with severe precipitation, these events are not anticipated on an annual basis. Indeed, they are due to exceptional weather conditions (except in the case of Bear Creek, where annual flooding is anticipated). As such, the probability of flooding in Redmond can be assigned the following values: a low probability of flooding on the Sammamish River, a high probability of flooding for Bear Creek, and a low probability of flooding for Lake Sammamish.

D. Warning

All flooding events would have a considerable amount of warning, in that it requires a severe weather event and substantial rain and/or snowfall to produce a flood condition that would not otherwise be anticipated by flood plain management strategies. Because the Sammamish River, Bear Creek, and Evans Creek flow north out of Lake Sammamish and because Lake Sammamish is a high-volume body of water, there are no true flash flood events in Redmond.

Flooding and the secondary hazards associated with flooding, such as landslides and sinkholes, are thus not compounded by a complete lack of warning. Mitigation in the form of comprehensive development regulations that establish zero-rise building elevations – based on future flow analysis and careful flood plain management strategies – have helped to assuage the hazards associated with high intensity flooding events by, in essence, extending the warning period.

II. Vulnerability

A. Natural

The most important threat to the natural environment related to a flooding event is the potential for damage to fish habitat – in particular, the salmon habitat. In Bear Creek, a major flood event, such as a 25- to 50-year flood, can result in channel altering events and ensuing morphological changes to riparian vegetation. While flooding events are a part of the natural regime in streambeds, increased development pressures, in particular, the added runoff associated with increased impervious surfaces, have compounded the occurrence of flooding in Bear Creek. A major flood can result in stream scour, with devastating impact on that year's fish run due to destruction of salmon eggs laid in the preceding fall. Short-term damage to

system stability include bank erosion, sedimentation, and downstream gravel recruitment. The potential of a major flood event is relatively high on Bear Creek, and the impacts of such a flood are high. As such, the risk to the natural systems of Bear Creek is given a high risk rating. Flooding events on the Sammamish River are given a low potential and low impact rating and are thus given a low risk to natural systems rating.

B. Manmade

The manmade environment is susceptible to flooding in terms of damage to structures caused by rising water levels and potential secondary hazards such as landslides. In that the vast majority of development in Redmond is either outside of the flood plain or built at an elevation that precludes the threat of damage, a low impact, low vulnerability rating is assigned to the manmade environment.

C. Systems

The most serious threat to the community systems is from obstructed or damaged access routes. The recent history of flooding events in Redmond reveals that blocked roadways were the most common problem associated with the flooding. These particular roadways are site-specific in terms of their vulnerability (i.e., at the base of an unstable slope or in a historic basis, such as Redmond Way beneath the railroad tracts). As such, community systems are given a moderate impact, moderate vulnerability rating.

III. Risk Rating

There is a high probability of low impact flooding along Bear Creek and Evans Creek, and thus a low risk rating. There is low probability of low impact flooding along the Sammamish River, and thus a low risk rating is assigned. There is a low probability of low impact flooding along the shores of Lake Sammamish, and thus a low risk rating is assigned for flooding in this area.

IV. Links

http://www.splash.metrokc.gov
http://www.floods.org/
http://www.ametsoc.org/ams
http://www.colorado.edu/hazards
http://www.usace.army.mil/
http://www.fws.gov/
http://www.weather.com/
http://www.usgs.gov/
http://www.fema.gov/
http://www.splash.metrokc.gov

HAZARDOUS MATERIALS

I. Hazard Profile

A hazardous substance is anything that may cause damage to persons, property, or the environment when hazardous substances are released into soil, water, or air. In the Puget Sound region, chemicals are manufactured, shipped, imported, and transported in increasing quantities throughout the region. As many as 700,000 products pose physical or health hazards that can be defined as hazardous chemicals. Each year, over 1,000 new synthetic chemicals are introduced. Hazardous substances are categorized as toxic, corrosive, flammable, irritant, or explosive. Hazardous material incidents generally affect an area that houses chemical manufacturers, distributors, and importers.

Toxic chemicals often produce injuries to communities, people, environments, and almost any part of the body they come in contact with, typically the skin and the mucous membranes of the eyes, nose, mouth, or respiratory tract. For example, "irritant gases, such as chlorine and ammonia, can produce a localized toxic effect in the respiratory tract; corrosive acids and bases can produce a local damage to the skin." Furthermore, hazardous chemicals released into the environment can penetrate water, food, and human processes. It is important to recognize that exposure to chemical compounds that are categorized as hazardous have the potential to develop adverse effects when exposed to vulnerable populations and environments.

Secondary Hazards: It is difficult to point out specific secondary impacts to hazardous materials fallout. Secondary effects to hazardous materials would depend strictly upon how the initial incident was handled. Secondary effects to hazardous materials would vary depending on various issues and procedures taken to solve the spill or leak. Secondary impacts to hazardous material could happen if there were instances of cross contamination, exposure without proper equipment, and contact with natural and manmade environments of any kind between dangerous chemicals. Secondary effects would also depend on the type of exposure and degree of exposure to the chemical(s) in question during the event.

A. Location

The City of Redmond could experience hazardous chemical fallout of some kind due to the presence of 256 facilities registered with the EPA. The potential for a hazardous materials incident exists within and nearby these facilities dependent upon the kinds of hazard materials handled at the facilities. While chemical incidents are infrequent, chemical incidents are capable of endangering the health of communities, individuals, first responders, and the environment of Redmond.

For a map and list of registered Hazardous Material facilities in Redmond, refer to the following: http://www.epa.gov/epahome/comm.htm and enter in the zip code.

B. Probability

The overall probability for exposure in Redmond to a hazardous material is relatively low. Redmond in not located on a major transportation corridor and only a single packinghouse stores a significant quantity of a hazardous chemical. Those working within the plant appear to be familiar with the handling of the ammonia stored on site. People most likely to encounter hazardous material exposure are emergency personnel that respond to emergency calls without being forewarned that hazardous materials may be involved.

C. Severity

The severity of toxic exposure depends on the kind and amount of toxins released. The route by which personnel are exposed to a compound also plays a role in determining the severity of the compound taken up by the body. A compound may be absorbed following exposure by one route more readily than by another. With that, the severity also depends on the duration of exposure to the compound and the concentration of the compound to which one is exposed. The relationship between the total amount of the compound absorbed by the body (dose) and the concentration of that compound in the environment will help determine the type of medical and emergency assistance to administer on the scene.

There is a low, medium, and high range that can be associated to the severity that again is dependent on the type of chemical, the amount, location, and infected environments. While transportation incidents attract larger media attention, statistics show that almost 75% of all acute hazardous material events, excluding fuel spills, occur in the fixed locations where they are used or stored. Hazardous material incidents can range anywhere from small releases at a factory site to rapidly expanding events that can endanger communities and environments.

II. Vulnerability

A. Natural

People, pets, livestock, and vegetation in close proximity to facilities producing, storing, or transporting hazardous substances are at higher risk. Populations further downstream, downwind, and in the periphery of released substances are particularly vulnerable depending on the substance and Emergency Management's attempts to contain the hazardous material leakage.

All ecological systems could be impacted to certain degrees depending on the volatiles. The natural environment can be vulnerable to a hazardous material incident depending on the location of the incident, the type of chemical, and its proximity to the natural environment. Redmond has various parks, natural forests, and Lake Sammamish that could all be impacted by a chemical toxin if released into the general environment.

B. Manmade

Manmade facilities, homes, and infrastructure are also vulnerable to a hazardous material incident depending on the location, type, and amount of toxins released and stored in manmade facilities. The system that carries and stores water could be impacted if specific toxins were deposited into drinking water.

C. Systems

A hazardous materials accident can occur almost anywhere in Redmond depending on the processes, for example: storage, shipping, development, etc., associated to the hazardous materials. In a severe event, there is potential for closure of public buildings, widespread business interruption, and economic losses while cleanup is completed. At least two of the wells have potential exposure to hazardous materials spills.

III. Risk Rating

The hazardous material incident can be given a high, medium, or low risk rating depending on the incident. This risk warrant could receive an overall medium risk rating, because there are facilities in Redmond that deal with hazardous materials on a daily basis. However, because the storage facility is easily accessible by response personnel, we have downgraded the rating to a low to moderate designation.

A "High" risk rating can be associated to hazardous materials housed in a factory or chemical storage facility when it exploded, leaked, or was broken into and chemicals were disrupted. This would endanger the surrounding community, environment, and systems. If outside resources had to be called in to help administer recovery, this could potentially be acknowledged as a high-risk incident.

A Medium risk incident might be a hazardous material incident if chemicals were spilled, exploded, or stolen within a close proximity of a vulnerable population and/or environment, but the local fire and police were able to contain the damage quickly, efficiently, and without outside jurisdictional assistance.

A Low risk rating would be associated to a chemical spill that was reported at a facility that exists in the periphery of Redmond and local emergency personnel were able to contain and clean up the hazardous material incident.

IV. Capabilities

Redmond Fire Haz-Mat teams, in cooperation with the Eastside Haz-Mat Team, have primary responsibility for an incident. The team is well trained and capable of managing foreseeable incidents. However, Public Works should also be added to the notification list for management of ground water contamination.

V. Links

For further information about hazardous materials:
http://www.hazmat.dot.gov
http://www.emergency.com/hzmtpage.htm

HEAT WAVES

I. Hazard Profile

"North American summers are hot. Most summers see heat waves in one section or another of the United States. East of the Rockies, summers tend to combine both high temperatures and high humidity, although some of the worst have been catastrophically dry. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. Among the large continental family of natural hazards, only the cold of winter – not lightning, hurricanes, tornadoes, floods, or earthquakes – takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the disastrous heat wave of 1980, more than 1,250 people died."

The numbers quoted in the previous paragraph represent deaths from the direct effects of a heat wave. The indirect, or secondary, effects include mortality and illness in people with existing health conditions, to the very young, and to the aged.

Source: http://weather.noaa.gov/weather/hwave.html

A. Location

The climate of Redmond, like the rest of the Pacific Northwest, is typically temperate and comfortable. Although heat waves can potentially occur in Redmond, they are unusual occurrences for the prevailing climate and residential woodland setting.

B. Severity

Historically, extremely high temperature periods in Redmond have been of short duration.

C. Probability

There are no known heat waves to have occurred in the Redmond area. There is a low probability of a heat wave of any magnitude affecting Redmond.

D. Warning

The National Weather Service issues alerts, advisories, and warnings of severe heat conditions. NWS bases its determination of whether to issue an advisory or a warning on the Heat Index (HI). Some regions and municipalities are more sensitive to heat than others. As a result, NWS has set different thresholds of extreme heat for different places. NWS uses a common guideline of maximum daytime HI that is expected to equal or exceed 105°F and an expected nighttime minimum HI of 80°F or above for two or more consecutive days for the issuance of excessive heat alerts. NWS issues the HI forecasts for zones and cities in special public information statements.

II. Vulnerability

A. Natural

The natural environment will be dried out by heat causing vulnerability to diseases and fire. Additionally, heat waves can cause an increase in water temperature. This in turn can be detrimental to fish habitat.

B. Manmade

It is not uncommon around the Puget Sound for houses not to have air conditioning, potentially leaving many people exposed to inhospitable environments. The most vulnerable are the elderly, small children, chronic invalids, those on certain medications or drugs, and persons with weight and alcohol problems.

C. Systems

During heat waves, the emergency medical and dispatch systems will work hard. It is likely that they will incur resource shortfalls.

III. Risk Rating

Redmond has a low risk for the occurrence of a heat wave of any length or severity.

IV. Links

Excellent resource – Social Aspects of Weather: Summer/Winter. National Center for Atmospheric Research Environmental and Societal Impacts Group
http://www.esig.ucar.edu/socasp/summer-winter.html

LANDSLIDES

I. Hazard Profile

Landslides are the release of rock, soil, or other debris and its subsequent movement down a slope or hillside. They are generally caused or controlled by a combination of geology, gravity, weather, groundwater, waves, and human activity. Although gravity acting on a steep slope is the primary reason for a landslide, they often occur as these factors converge or are triggered by an event such as a large earthquake.

Other causes and contributing factors include:

- Erosion by rivers, glaciers, or ocean waves creates overstepped slopes.
- Rock and soil slopes are weakened through saturation by snowmelt or heavy rains.
- Earthquakes create stresses that make weak slopes fail.
- Volcanic eruptions produce loose ash deposits, heavy rain, and debris flows.
- Vibrations from machinery, traffic, blasting, and even thunder may trigger failure of weak slopes.
- Excess weight from accumulation of rain or snow, stockpiling of rock or ore, from waste piles, or from manmade structures may stress weak slopes to failure.
- Poor development practices

Slope material that becomes saturated with water may develop a debris flow or mud flow. The resulting slurry of rock and mud may pick up trees, houses, and cars, thus blocking bridges and tributaries and causing flooding along its path.

Landslides vary greatly in size and composition, from a thin mass of soil a few yards wide to deep-seated bedrock slides miles across. The travel rate of a landslide can range from a few inches per month to many feet per second depending on the slope, type of material, and moisture content.

A. Location

The Puget Sound region is relatively prone to landslides, especially where combinations of slopes, soils, geology, and vegetation are made susceptible to movement resulting from impacts

of heavy rains, ground tremors, forest fires, or other environmental shocks. Examples include areas of regular debris flows or where pumping of underground aquifers occur.

Within the City of Redmond, many areas are characterized by steep slopes and are at risk of landslides. The largest contiguous areas are the northwestern slopes above Lake Sammamish, north of Redmond-Kirkland Road, and eastern slopes north of Avondale Road. Currently developed with low-density, single family homes, the area is generally wooded and interspersed with native vegetation along several ravines feeding the lake below.

B. Severity

The State of Washington rates landslide losses second to flood losses for the state as a whole, with the Puget Sound basin having the greatest vulnerability. This is because of increased population density and development on and below bluffs and slopes.

As referenced in a series of sensitive area maps, Redmond has several landslide hazard areas ranging from low to very high hazard rating. Areas with the largest landslide risk are generally at some distance from development, although an event would likely impact roads and lifelines.

Slopes with vegetation such as trees and shrubs can be less vulnerable to surface slides depending on the root depth relative to the slip plane. Root systems serve the function of stabilizing hillside banks, giving soils more structure. Since Redmond's eastern neighborhoods are generally wooded in the steepest areas, potential impacts may have been lessened.

C. Probability

There are many active slide areas identified within the City. These have been mapped and may flow into homes or block major roads. During periods of heavy moisture, these areas could easily be triggered.

> ***Warning***: Generally speaking, the highest risk landslides are very fast moving and provide little advance warning. Tilting trees can provide a visual warning system to slower-moving landslides. Other immediate danger signals include rapid water or slurry flow impacting the structure, irregular flow that precedes debris dam bursting, ground or structural cracks opening, structures making noises, and walls and/or floors tilting. These cases would signal the need to evacuate immediately.

II. Vulnerabilities

A. Natural

Natural system losses may include trees, shrubs, and stream ecology along the series of east-west ravines, the Lake Sammamish shoreline, public park areas, and related wildlife.

B. Manmade

Manmade elements vulnerable to landslides include loss of or damage to homes, private property, public buildings, and commercial enterprises. These may be buried, shifted off foundations or otherwise made unstable. Human lives are potentially at stake from a fast-moving landslide. Lifelines and infrastructure may be blocked, limiting residents' access to

roads, power, and communications especially during an area-wide problem such as an earthquake event.

Redmond's eastern neighborhoods are particularly isolated, being bounded by the lake to the east, steep slopes to the west, and generally characterized by a series of cul-de-sacs extending into ravines. Homes that depend upon the few roads that run north-south are especially vulnerable if landslide debris outflows onto the roads below.

The potential number of residents impacted relate to the number of homes located on or above the slope, number of homes below a potential debris outflow, and number of homes built before the landslide building code went into effect.

If future development continues in high-risk areas, vulnerability will increase. The greatest risk is to individual residential structures on or below bluffs or slopes and those residents who rely upon landslide-vulnerable roads, pipelines, and electrical and communications lines.

Residents in multifamily housing developments along Avondale Road are particularly at risk, as are West Lake Sammamish neighborhoods relying upon Lake Sammamish Boulevard.

C. Systems

Depending on the degree that lifelines are blocked, business interruption could result and government's provision of services may be compromised.

III. Risk Rating

The Puget Lowland bluffs have experienced landslides for thousands of years. Bluff retreat is a normal process. Some of the small-scale but still potentially destructive retreats occur continuously. The larger landslides tend to be more episodic. When heavy winter precipitation is added to bluff sediments, unstable parts of the slope tend to fail. The frequency over time and space of these failures increases during and after particularly heavy rains. In some places, human activities, such as poor construction practices, have exacerbated the rate of bluff retreat by land sliding.

Given that Redmond has several steep-sloped areas bordering a lake and landslides are commonly a secondary hazard associated with earthquake, winter storms, and many other contributing causes, there is a high probability of their occurrence in these locations. However, the combination of low-density residential zoning, quality development practices, engineered drainage solutions, native or remnant landscaping, and the ample resources of its residents temper the severity of expected impacts. Even if individual losses are lessened by these measures, interruption to lifelines, access, and business activity may still occur bringing the rating up again. Because of this, a high risk rating is assigned.

IV. Links

United States Geological Survey – Program on Landslides
http://landslides.usgs.gov/html_files/landslides/program.html
Washington State Department of Natural Resources – Landslide documents
http://www.wa.gov/dnr/htdocs/ger/landslid.htm

Puget Sound Bluffs: The Where, Why, and When of Landslides Following the Holiday 1996/97 Storms, by Wendy J. Gerstel, Matthew J. Brunengo, William S. Lingley, Jr., Robert L. Logan, Hugh Shipman, and Timothy J. Walsh.

TERRORISM

I. Hazard Profile

The terrorists of today are not under any one person's or nation's control and governance but are associated with various national and international communities and movements.

Domestic Terrorism: The unlawful use or threat of force or violence by a group or individual based and operating entirely within the United States and without foreign direction.

International Terrorism: The unlawful use of force or violence committed by a group or individual who has some connection to a foreign power.

Secondary Hazards: The secondary hazards of a terrorist attack could range anywhere from minor to severe effects depending on the type of attack and location. In any event, there is the possibility of community utilities being impacted.

A. Location

Businesses in Redmond could become targets for terrorism. The high profile businesses that would be symbolic are located along the SR 520 corridor between downtown Redmond and Bellevue.

B. Severity

This information is under a separate cover and is not for publication.

C. Probability

Recent terrorist acts include the 1988 bombing of Pan Am Flight 103 over Lockerbie, Scotland, the 1993 bombing of the World Trade Center in New York City, the 1995 bombing of the federal office building in Oklahoma City, and the 1996 bombing at the Atlanta Olympics. In 1995, a militia group committed a series of domestic terrorist acts and bank robberies in Spokane to bring attention to their cause and to finance their militia activities.

With this increase in terrorist activities within the past few years, it could be conceivable that a domestic or international terrorist attack could happen in Redmond. Therefore, it is in the best interest of the City to initiate a comprehensive analysis of potential terrorist targets in the City and measure the present capabilities that the City has to deal with such threats.

There is no known record or documentation of terrorist activities within Redmond's city limits. However, the recent capture of known terrorist Hamad Rasam shows that terrorism in the Pacific Northwest is becoming a real danger.

II. Vulnerabilities

A. Natural

Drinking water, air, and public parks could be potential terrorist targets.

B. Manmade

Considering the "international crossroads" of Redmond's many world headquarters, these and other entities could be targeted.

- Microsoft Corporation
- Safeco Insurance
- AT & T Wireless Headquarters
- Hospitals
- Research Facilities
- Technology Research Facilities
- Sources for Drinking Water
- Olympic Williams Pipeline
- Nintendo Corporation
- Group Health Substations
- Rocket Research Facilities
- Public Facilities/Parks
- Fuel Depots

C. Systems

Some of the systems in Redmond that would be potential terrorist targets are the Olympic Pipeline system, transportation system, and public support systems like retirement homes, public housing, sewer systems, drinking water systems, and computer systems.

III. Risk Rating

Terrorist activities in Redmond have a moderate vulnerability rating. The City of Redmond is home base to many businesses that operate internationally, providing a range of potentially interesting targets for a terrorist "looking to make a statement."

IV. Links

For further information on terrorism, please refer to the following links.

http://www.terrorism.com/index.shtml
http://www.fema.gov/library/terror.htm
http://www.fema.gov/nwz01/nwz01_33.htm
http://www.st-and.ac.uk/academic/intrel/research/cstpv/

WILDFIRE

I. Hazard Profile

A wildfire is "any instance of uncontrolled burning in grasslands, brush, or woodlands," whereas “uncontrolled burning within a forested area is a forest fire.” For most of this hazard profile, the word "wildfire" encompasses “forest fire” as well. The distinction is important mainly to clarify that wildfires do occur in non-forested areas.

Hazards Secondary to Wildfire/Forest Fire:

- Landslides, mudslides, more intense water run-off (potential long-term hazard)
- Deadfall of scorched trees (potential long-term hazard)
- Ignition source for flammable and explosive materials
- Smoke and particulates reduce air quality – trouble especially for people with respiratory ailments
- Volatilized hazardous waste – toxic clouds or plumes
- Damaged infrastructure, such as roads, water supply pipes, sewer, presents possible health and safety risks.

The wildfire near Los Alamos, New Mexico (Cerro Grande Fire) in May of 2000 is an interesting case study of a wildfire and its secondary hazards. The Cerro Grande Fire also exhibited the classic characteristics of a hard or impossible to control wildfire moving from wildlands to urbanized areas through the urban/wildland interface.

Sources:

The Los Alamos Cerro Grande Fire: An Abject, Object Lesson
http://www.Colorado.EDU/hazards/o/whtmtst.htm
Cerro Grande Fire, National Park Service, Bandelier National Monument
http://www.fs.fed.us/r3/sfe/fire/cerrogrande/

Urban/Wildland Interface

The urban/wildland interface is the area or areas in which houses and non-residential structures, like businesses, public buildings and utility stations, encroach on an undeveloped, natural resource area. The term, "wildland" seems inappropriate to describe the undeveloped areas in Redmond. In the case of Redmond, the interface may be better described as the places where houses and other structures are up against and amidst trees, brush, and grassy areas whether or not residents consider these areas "wild."

The other important distinction in the description of fire hazard for Redmond is that a conflagration of burning structures, houses, or commercial buildings is different than a wildfire. The distinction becomes blurred in the case of a fire underway in the interface between structures and wildlands.

A. Location

The location and extent of a wildfire will depend upon land cover, topography, and weather. In theory, a wildfire continues to blaze and cover more ground until it runs out of fuel or the conditions conducive to fire terminate.

B. Severity

The severity of wildfire in Redmond will depend upon the same conditions as described in Location. Wildfires are of an interesting subset of hazards that perpetuate themselves. For these hazards, the severity of the hazard dictates the location and extent of the hazard.

Three rankings of severity of wildfire range as follows:

High: An intense, all-consuming fire that affects large acreage in Redmond either in several locations or as a contiguous front. The possibility of secondary hazards as a result is high.

Moderate: An intense, all-consuming fire that affects small acreage in Redmond, perhaps spotty in several locations, or a cooler fire that burns the available fuels less completely over a large area.

Low: An intense, all-consuming fire in a small, discrete area, or a cooler fire that burns the available fuel less completely over a small area.

C. Probability

Under normal conditions, there is a low probability of a widespread wildfire in Redmond. The probability increases in long periods of drought, such as the prevailing conditions of 2000 to 2001, and when there is extra fuel available following a cycle of new growth from earlier heavy rains.

Fire cycles in the Western Cascades range from 200 to 400 years. The intervals between major fires increase in length from the south to the north. Experts have dated three massive, regional fire episodes in the past 750 years.

"In normal summers, sparks during dry spells can burn withered grasses, needles, and underbrush, but larger materials – the so-called 1,000-hour fuels of thicker standing or downed timber – retain enough moisture that they merely smolder" (Welch). Drought conditions significantly increase the odds of catastrophic fire occurrence. Long periods of dry conditions, large amounts of drying fuel, and wind make for wildfire outbreaks. The necessary spark for a fire may come from human activity or natural sources like lightning.

Usually, there are about 1,500 lightning strikes during the summer and early fall in Washington. However, in August of 1999 there were more than 10,000 strikes in less than one week.

Regional Wildfire History

In 1995, 80-mph winds stoked a previously extinguished fire in a Plum Creek Timber slash pile into a 300-acre wildfire that threatened Cumberland, Washington. In the summer of 1991, summer fires burned 700,000 acres along the western Cascades from Eugene, Oregon to

Bellingham, Washington. One hundred years ago, the Yacolt Fire in southwest Washington, killed 38 people in 36 hours and charred 240,000 acres. A wildfire in 1701 burned from Shelton to Port Angeles. Scientists believe that event was linked to a big subduction zone earthquake in the previous year that created massive fuel loading in the form of toppled, dead trees.

Factors that contribute to the likelihood of wildfire occurrence:

- Hot, droughty weather
- Wind
- Fuel loading
- Ignition sources, human and natural
- Steep slopes – fire moves quickly up a slope, slowly down a slope
- Aspect and the accompanying effect on temperature and evaporation

Sources:

Craig Welch, Seattle Times Staff Reporter, 2001. "Wildfire Worries: Sweating in Our Dry State" Seattle Times, Local News: Sunday, April 08, 2001.
http://archives.seattletimes.nwsource.com/cgi-bin/texis/web/vortex/display?slug=wildfire08m&date=20010408&query=wildfire
Wildland Fire Assessment System
http://www.fs.fed.us/land/wfas/welcome.htm

D. Warning

The Seattle office of the National Weather Service has a fire weather office charged with providing information about fire danger through forecasts and outlooks of weather conditions conducive to wildfire.

Link: http://www.seawfo.noaa.gov/fire/olm/fire/seafwx.htm

II. Vulnerability

A. Natural

Human lives are at risk in a wildfire. The trees, shrubs, and grasses that make up the fuel for the fire and the habitat they provide are vulnerable. The increased run-off (secondary hazard) after a fire could impair salmon runs.

B. Manmade

Homes, commercial buildings, public buildings, and other structures tucked in amongst trees and brush are at a greater risk for wildfire. Landscaping in Redmond often encourages the planting and growth of combustible vegetation immediately surrounding the structure.

C. Systems

Disruption to business, economic, and residents' daily activities is a systemic vulnerability. If the City's residents needed to evacuate, traffic congestion and access in and out of Redmond could

be very significantly compromised, creating greater risk to human life. The same is true for traffic flowing through the Redmond area.

Redmond has a low vulnerability to widespread wildfire under normal weather conditions. The infrequency of wildfire in Redmond, however, may actually increase the vulnerability to wildfire by discouraging preventative measures in site planning, landscaping, and construction that could reduce overall vulnerability. In prolonged drought periods, the vulnerability of Redmond to wildfire increases enough to warrant action.

The FIREWISE website has an interactive tool online that allows the user to assess risk rating for an individual home in the urban/wildland interface. http://www.firewise.org/pubs/WHAM/nfpa/

III. Risk Rating

Redmond has a low, but significant, level of risk of widespread wildfire under weather conditions that accompany periodic droughts. The risk of localized wildfire outbreaks is moderate under the same conditions.

An overall low risk rating was given in a large part because of the City of Redmond's fire suppression capability. The City has a well-trained and funded Fire Department, the road and hydrant networks are excellent, and all properties have addresses.

IV. Capability

Outdoor burning regulations adopted by the Puget Sound Clean Air Agency (PSCAA) prohibit outdoor fires in the "carbon monoxide non-attainment area." This area, defined by PSCAA, includes the urban areas of King, Pierce, and Snohomish counties. The entire City of Redmond and portions of King County Fire District 34 fall within this no-burn area.

With a burn permit, Redmond Fire Department and King County Fire District 34 will allow residential and land clear burning in some areas of the fire district during the months of March, April, May, October, November, and December. The permitting process regulates air quality and serves to prevent wildfire ignition sources.
http://www.ci.redmond.wa.us/insidecityhall/fire/prevention/permitsburn.asp

Private citizens in Redmond can take simple, practical measures to improve the fire resistance of their property. To reduce the threat of a fire starting around your home or of having your home swept up in a nearby fire, the Department of Natural Resources recommends the following precautions.

- Ask your power company to remove or prune trees that could fall and break a power line.
- Visibly post your home address and clear away driveway obstacles to improve emergency vehicle access.
- Locate nearby sources of water that firefighters can tap.
- Create a fire-defensible space by moving stacked firewood and other flammable materials away from your home.
- Develop home landscaping that emphasizes open space and fire resistant plants.

- Clear your roof and gutters of tree leaves and needles, and trim back overhanging vegetation.

V. Links

PSCAA: http://www.pscleanair.org/
Redmond Fire: http://www.ci.redmond.wa.us/insidecityhall/fire/fire.asp
http://www.wa.gov/dnr/htdocs/adm/comm/nr01-034.htm

WINTER STORMS

I. Hazard Profile

Destructive storms come in several varieties: wind, rain, ice, snow, and combinations. Nearly all destructive local storms occur from November through April when the jet stream is over the West Coast and Pacific low-pressure systems are more frequent. The trajectory of these systems determines their effect locally. The more southerly ones bring heavy rains while the more northerly ones bring cold air and the potential for snow and ice. Any winter storm, regardless of its trajectory, can pack high winds. Generally, winds above about 30 miles per hour can cause widespread damage, and those above about 50 miles per hour can be disastrous.

A. Location

The entire City of Redmond is vulnerable in a severe winter storm. Microclimates within the area vary in vulnerability to specific storm impacts, such as ice jams, wind exposure, or lightning.

B. Severity

Redmond's hillside and valley topography creates a wind tunnel, increasing exposure and behavior of air movement and bringing snow, ice, or heavy rains. Since residential development patterns are somewhat isolated in cul-de-sacs feeding off a common arterial, there is a high degree of reliance on a few key roads, so residents may be at risk by limited access. Damage due to saturated ground and falling trees also raises the severity rating.

C. Probability

Storm history, evidenced by the Winter Storm of 1996-97, the Columbus Day Storm of 1993, and the Inaugural Day Storm of 1962, suggests a high probability of occurrence in the City of Redmond and the Puget Sound region.

D. Warning

Weather reports and forecasts provide a few days lead-time in predicting the timing and severity of storm system impacts.

II. Vulnerability

A. Natural

In the event of a winter storm, natural systems continue to adapt and change. Prolonged heavy rains cause the ground to be saturated, rivers and streams to rise, and often result in local flooding and landslides. Melting snow adds to river loading and can turn an otherwise benign situation into a local disaster.

While there may be losses or environmental change impacting vegetation, stream or shoreline ecology, parks, or related wildlife, these features may be more vulnerable to human activities disrupted by the storm, such as wastewater overflows, petroleum pipeline bursts or other chemical spills, diverted groundwater recharge, and poor development practices, for example.

B. Manmade

Winter storms can be deadly. Human life is especially vulnerable from exposure in freezing weather, accidents while driving or falling on icy roads, injury or death from falling trees, and downed power lines. Falling trees and debris may damage homes, private property, public buildings, and commercial enterprises. Snow accumulations can cause roofs to collapse. Snow accompanied by high winds is a blizzard, which can affect visibility, cause large drifts, and strand residents for up to several days. Residents without food or water may attempt to use impassable roads and thereby increase the number of potential rescues.

C. Systems

High winds can cause widespread damage to trees and power lines and interrupt transportation, communications, and power distribution. Snow or ice storms can impact transportation, electrical, and telecommunication systems. These storms also disrupt the response. In general, the lifeline infrastructure may be compromised, such as limited access to roads, power, and communication. Widespread business interruption and economic losses would be expected.

D. Vulnerability Rating

This is a medium-density, residential population. Within the urban area, the access to provision of services exposure is relatively low; however, access and response capabilities may be limited.

III. Risk Rating

Medium to high risk. The storm and ice have the capability of isolating many people in the Puget Sound region, while turning out the lights.

IV. Links

Winter Storms Fact Sheet- http://www.fema.gov

Hazard Identification Vulnerability Analysis Attachment Guide

Attachment One: Seismic Hazard-Land Use Map

Attachment Two: Landslide Hazard-Land Use Map

Attachment Three: Wetlands

Attachment Four: Aquifer Recharge Area

Attachment Five: Critical Erosion Hazard Areas

Attachment Six: Floodplains

Attachment Seven: Streams Classification

Attachment Eight: Red Zone District 34

Attachment Nine: Risk – Wildfire Urban Intermix in King County, WA

Attachment Ten: Critical Facilities List